First- and second-rotation yields of willow clones at two sites in New York State

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Yield is an important factor influencing the economic return from willow biomass systems. Research in Europe indicates that willow coppice yields increases significantly from first to second rotation, but that the increase can vary between clones and sites (S. Larsson, personal communication, 2001). SUNY-ESF is involved in a network of 21 willow biomass trials to determine the interaction between clones and site factors. Two trials have been harvested twice and provide some insight into changes in production in successive rotations.

Trials were established in New York State in 1993 at Massena ($44^0$59' N, $74^0$46' W) on a poorly drained, Rhinebeck silty clay and at Tully ($42^0$47' N, $76^0$07' W) on a well-drained, Palmyra gravelly, silt loam. No-till site preparation was used at Massena, while a combination of chemical and mechanical techniques were used at Tully. Unrooted dormant cuttings from 14 and 19 willow clones respectively were planted at Massena and Tully using a double row planting design with a density of 15,100 plants ha^{-1}. Plants were coppiced during December 1993 and fertilized with N, P and K at elemental rates of 112, 34, and 78 kg ha^{-1} in the spring of 1994. First- and second-rotation harvests at Tully and Massena occurred in the winter of 1996 and 1999 and 1997 and 2000 respectively. The first harvest at Massena was delayed due to deer browse damage. Following first-rotation harvests, Tully was fertilized with 1.25 cm thick layer of composted chicken manure (TKN = 670 kg ha^{-1}), and Massena with 100 kg N ha^{-1} as sulphur coated urea.

First-rotation production at Massena ranged from 3.4 – 9.2 odt ha^{-1} yr^{-1} (Figure 1) with an overall mean of 5.1 $\pm$ 2.0 odt ha^{-1} yr^{-1}. Second-rotation production was 7.3 to 19.8 odt ha^{-1} yr^{-1}, with an overall mean of 10.6 $\pm$ 2.2 odt ha^{-1} yr^{-1}. Second-rotation average annual production across all clones increased by 133%. Individual clones had average annual production increases of 39 to 273%. The increase in average annual production for 13 of the 14 clones was significant (? = 0.10). The clonal production ranking of first and second rotation yield was significantly correlated (Spearman rank correlation coefficient = 0.70, p = 0.005).

First-rotation production at Tully ranged from 2.8 to 8.9 odt ha^{-1} yr^{-1} with an overall mean of 5.2 $\pm$ 1.8 odt ha^{-1} yr^{-1}. Second-rotation production ranged from 3.9 to 10.7 odt ha^{-1} yr^{-1}, with an overall mean of 6.7 $\pm$ 1.8 odt ha^{-1} yr^{-1}. Across all clones, second-rotation average annual production increased by 35%, while individual clones increased by 5 to 65%. The increase in average annual production was only significant (? = 0.10) for 11 of 19 clones. The clonal production ranking of first and second rotation was significant (Spearman rank correlation coefficient = 0.77, p = 0.001).

The clonal ranking of first-rotation production at Massena was correlated with the ranking for the first rotation at Tully (Spearman rank correlation coefficient = 0.66, p = 0.01). This suggests that through the first rotation the clones responded similarly at the two sites. However, the variable changes in production of the clones during the second rotation resulted in a non-significant correlation between Massena and Tully after the second harvest (Spearman rank correlation coefficient = 0.18, p = 0.52).

Variation in the production increase from first to second rotation is due to differences in soil characteristics, weather, site preparation, and the interaction with different clones. Other factors affecting production include insect and disease damage, and deer browse. Deer browsing damage was observed on 10 of the 14 clones at Massena in 1994, which caused the extension of the first rotation to four years, while none of the clones were browsed by deer at Tully. The 1999 growing season was extremely dry, so differences in drainage class and moisture holding capacity of the soils at the two sites interacting with clonal responses to drought influenced second-rotation production. The large increase in second-rotation production at Massena is probably due to a combination of the longer first-rotation, which lowered the annual production, and the less droughty soils. The correlation ranking of clones between the two sites was significant in the first rotation, but changed during the second rotation suggesting that the clones responded differently to the site and weather conditions. Further analysis of the factors driving these changes will be presented.

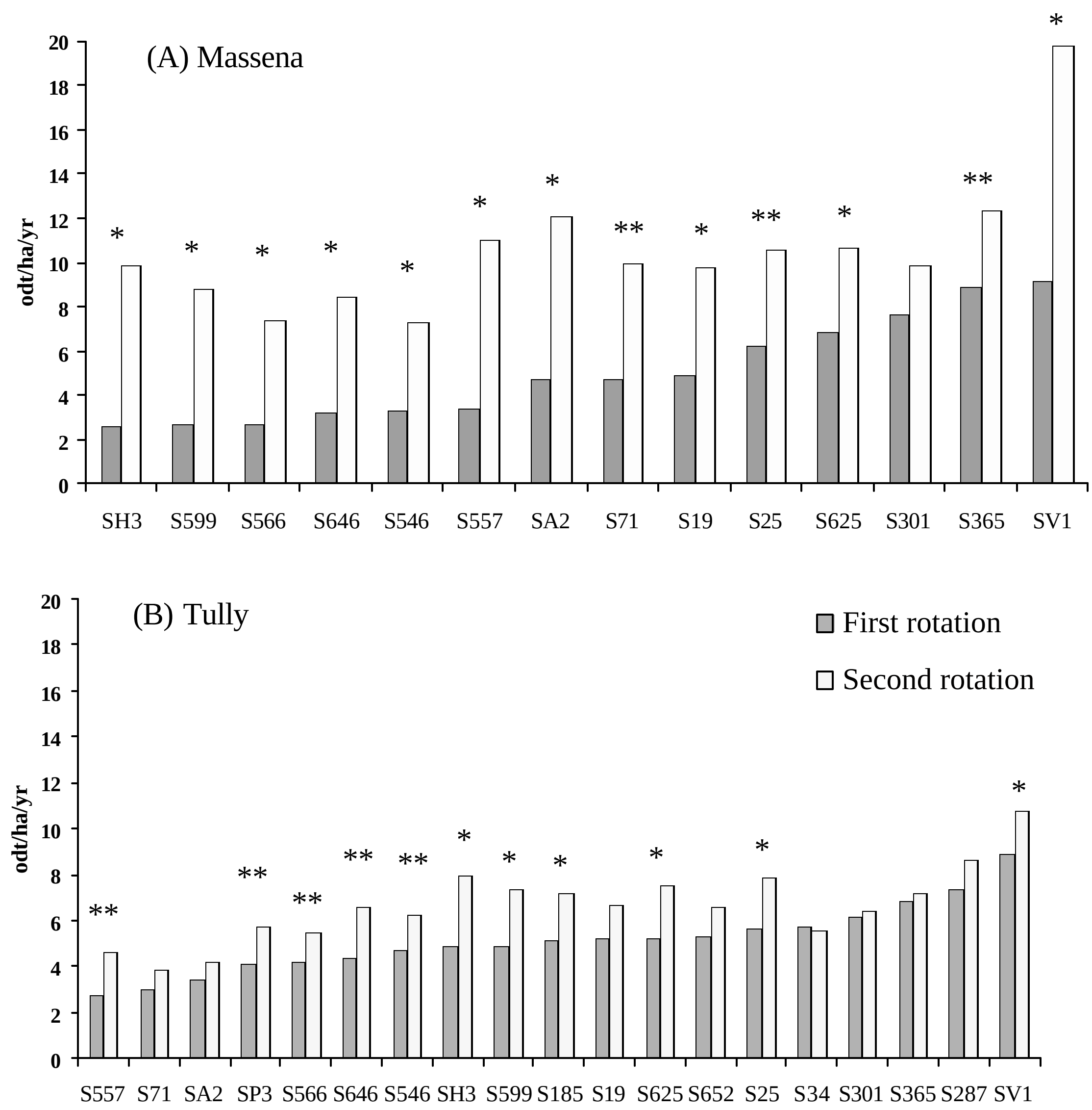

Figure 1. First and second rotation harvests for 14 and 19 clones respectively at (A) Massena and (B) Tully, NY (* and ** indicate that results of a paired t-test between second and first rotation were significant at ? = 0.05 and ? = 0.10 respectively).